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(71) Applicant *(for all designated countries except the U.S.)*: ENGINION AG [DE/DE]; Gustav-Meyer-Allee 25, 13355 Berlin (DE).

(72) Inventor; and

(75) Inventor/applicant *(only for the U.S.)*:CLEMENS, Herbert [DE/DE]; Nusshaeherstrasse 39, 13505 Berlin (DE).

(74) Attorney: WEISSE, Jürgen et al.; Bökenbuschstr. 41, 42555 Velbert (DE).

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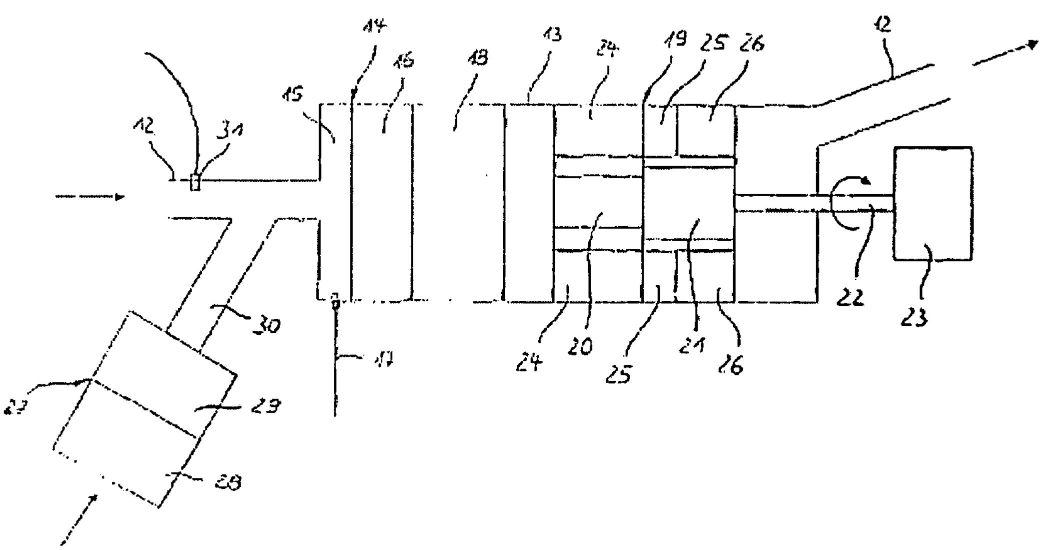
(54) Title: DEVICE FOR PRODUCING MECHANICAL ENERGY

(57) Abstract: The invention relates to a device for producing mechanical energy. Said device contains an internal combustion engine and an expansion engine (20,21) which is fed with superheated steam from a steam generator. Exhaust gases of the internal combustion engine are injected into the steam generator (24) to use the waste heat thereof. In order to eliminate pollutants and non-burned fuel in the exhaust gases of the internal combustion engine in a simple and effective manner, the steam generator (24) is heated by a non-catalytic burner (16) at a burner temperature of between 1100° and 1300°C. The exhaust gases of the internal combustion engine can be combined with the combustion gases in the burner (16). The afterburning of non-burned fuel and the combustion of pollutants is thus carried out in a burner (16) in a non-catalytic manner. The combustion gases in said burner (16) are at a temperature such that non-burned fuel parts in the exhaust gases of the internal combustion engine which are introduced into the burner are afterburned, but form, however, essentially no nitrogen oxides at excessive temperatures. The burner (16) is used to heat the steam generator (24) and can be designed according to the energy requirement of the steam generator (24) and the expansion engine (20,21). The heat of the exhaust gases of the internal combustion engine is used to generate steam.



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Device for Producing Mechanical Energy

Technical Field

The invention relates to a device for producing mechanical energy. Said device contains an internal combustion engine and an expansion engine, which is fed with superheated steam from a steam generator. Exhaust gases of the internal combustion engine are injected into the steam generator to use the waste heat thereof.

Background Art

The DE 196 10 382 C2 describes a combined engine, which comprises an internal combustion engine and an expansion engine in the form of a steam engine. The steam engine receives high pressure steam from a steam generator. The high pressure steam is preheated by cooling the engine block of the internal combustion engine. The steam generator is supplied with exhaust gases of the internal combustion engine. The internal combustion engine and the steam engine work on a common crankshaft. The exhaust gas line, which runs by way of the steam generator into the atmosphere, has an oxidation catalyst upstream from the steam generator to filter the pollutants out of the exhaust gases. The DE 196 10 382 C2 proposes that fuel be injected intermittently or continuously into the exhaust gas line upstream of the catalyst for the purpose of increasing the energy output ratio of the steam engine. This additional fuel is burned together with the unburned fuel from the engine in the catalyst.

An afterburning of the unburned fuel from the internal combustion engine is carried out in the conventional manner by means of an oxidation catalyst. The steam generator uses primarily the waste heat of the exhaust gases, including the combustion heat released in the oxidation catalyst. Additional fuel can be introduced into the oxidation catalyst only to increase the energy output of the steam generator even more.

The quantity of fuel, which can be burned additionally in the oxidation catalyst, is limited by the constructive properties of the oxidation catalyst. The oxidation catalyst is designed to afterburn the residual unburned fuel in the exhaust gases or specific pollutants, but not to serve as a source of heat for a steam generator. The steam engine, working on the same crankshaft as the internal combustion engine, is to use essentially only the heat of the exhaust gases and, thus, to improve the efficiency.

Disclosure of the Invention

The object of the invention is to improve in a device of the class, described in the introductory part, the output energy of the steam generator.

Another object of the invention is to eliminate in a simple and effective way the pollutants and unburned fuel in the exhaust gases of the internal combustion engine.

The invention solves these problems in that the steam generator is heated by a non-catalytic burner at a burner temperature ranging from 1,100° to 1,300° C and that the exhaust gases of the internal combustion engine can be combined with the combustible gases in the burner.

Thus, in the invention the afterburning of the unburned fuel and the combustion of pollutants is carried out in a burner in a non-catalytic manner. The combustible gases in this burner have such a temperature that, on the one hand, unburned fuel parts in the exhaust gases of the internal combustion engine, which are introduced into the burner, are afterburned, but form, on the other hand, essentially no nitrogen oxides at excessive temperatures. The burner serves to heat the steam generator and can be designed according to the energy requirement of the steam generator and the expansion engine. The heat of the exhaust gas of the internal combustion engine is used to generate steam.

The non-catalytic burner can be a porous burner. Preferably the non-catalytic burner and the internal combustion engine can be operated with the same type of fuel.

Upstream of the burner is preferably a mixing chamber, into which are fed the hot exhaust gases of the internal combustion engine. Fuel can be injected into the hot exhaust gases to produce a combustible gas for the burner. The hot exhaust gases are used to evaporate the fuel and to produce a combustible gas in the mixing chamber.

The burner exhibits preferably air supply means. The air supply means can feed combustion air into an exhaust gas line upstream from its opening into the mixing chamber. The air supply means can exhibit a blower. Upstream of the air supply pipe's discharge into the exhaust gas line a sensor can be disposed to measure the oxygen content in the exhaust gas. The blower is then controllable as a function of this oxygen content.

The burner can be followed by a pollutant catalyst or a soot filter or both. The pollutant catalyst and the soot filter are disposed upstream of the steam generator.

Such a downstream pollutant catalyst burns the residual pollutants, which have not been burned yet by the burner or have reformed, for example, in the form of nitrogen oxides in the burner. The pollutant catalyst has to be designed only to burn the rest of the pollutants. The pollutant catalyst is quickly heated by the burner's hot exhaust gases, which have not been cooled yet by the steam generator. Even the soot filter, which is made, for example, of ceramic, is heated so that the soot particles are burned therein.

One embodiment of the invention is explained in detail below with reference to the associated drawings.

Brief Description of the Drawings

Figure 1 is a schematic side view of an internal combustion engine with exhaust gas line and integrated steam engine as an expansion engine.

Figure 2 is a detailed, yet schematic drawing of the steam engine of Figure 1.

Figure 1 depicts a typical piston engine 1 as an internal combustion engine, comprising an engine block 2, a cylinder head 3, which is mounted on said engine block, and an oil pan 4, which is located underneath. The piston engine 1 exhibits five cylinders, the outlet of each empties into an exhaust manifold 6 to 10. The exhaust manifolds 6 to 10 empty into a collector 11, from which issues a main exhaust pipe 12. The main exhaust pipe 12 exhibits an expansion 13, into which is installed an expansion engine in the form of a steam engine of the type, described in detail in Figure 2.

As shown in Figure 2, the main exhaust pipe 12 empties into a combustion device 14. The combustion device 14 is arranged coaxially to the main exhaust pipe 12. The combustion device 14 exhibits on the input side a mixing chamber 15 and thereafter a burner 16 in the form of a porous burner. A porous burner exhibits, as well-known, a burner body, which is made of porous ceramic material. In the porous burner body a mixture of combustible gas and air is burned without an open flame. A flame front runs inside the porous burner body. Hot exhaust gas leaves the burner body as the combustion products. However, the described device can also operate with other suitable burners.

Fuel is injected by means of fuel injection means 17 into the mixing chamber 15. This fuel is of the same type as that with which the piston engine 1 is also supplied. The injected fuel mixes with the hot exhaust gases of the piston engine and is simultaneously evaporated. In the burner 16 the mixture is burned without a flame at a very homogenous temperature distribution ranging from 1,200° to 1,300° C.

A pollutant catalyst 18, which can be designed as a simple oxidation catalyst, is connected immediately to and axially downstream of the combustion device 14. Due to the direct connection, the pollutant catalyst 18 is heated up extremely fast after startup so that there is very low emission at startup. To the extent that the piston engine 1 is a diesel engine, there is a soot filter, based on ceramic, for example, instead of the pollutant catalyst 18. Owing to the combustion device 14, which is connected directly upstream, the soot filter can be heated to an extremely high temperature so that the soot particles burn, with the result that the soot filter is cleaned off.

Then a steam engine 19, which exhibits in succession a first expansion step 20 and a second expansion step 21, is arranged in turn coaxially. From said expansion steps issues a coaxial drive shaft 22, which drives, outside the exhaust pipe 12, a generator 23 to produce electric current for the direct supply of current consumers or for a motor vehicle battery. Instead of this, auxiliary units, such as the compressor of an air conditioner, can be driven directly.

The second expansion step 21 is enveloped by a first steam generator 24, which exhibits a ring-shaped heat exchanger, through which flows the heating gas, produced in the combustion device 14, and which is not shown here in detail. Feed water, which comes from a feed water preheater, which is not shown here in detail, flows through the first steam generator 24. Thereafter, said feed water flows into a second steam generator 25, which envelops the first expansion step 20, and through which also flows the heating gas, produced in the combustion device 14. The steam that is

produced in this way is then expanded to a mean pressure in the first expansion step 20. After this first expansion the steam is raised once again to a higher temperature in an intermediate superheater 26 and expanded to a low pressure in the subsequent, second expansion step 21. Thereafter the steam is fed to a condenser in a closed system, which is not shown here in detail. In the condenser, the steam is totally condensed into feed water. The feed water is then recycled into a reservoir. The output, which can be used industrially, is realized in the two expansion steps 20, 21. The result of the intermediate superheating is higher efficiency.

Such closed systems are well-known (DE-Z "MTZ Motortechnische Zeitschrift", volume 61 (2000) pp. 314-323) and are, therefore, not described in detail here. Heating gas also flows axially through the intermediate superheater 26. The intermediate superheater envelops, like a jacket, the two expansion steps 20, 21. Thereafter, the heating gas passes again into the main exhaust pipe 12, which continues tapered off.

To the extent that the piston engine 1 is designed as a diesel engine, the excess air in the exhaust gas usually suffices to support combustion in the combustion device 14. In Otto engines, the excess air is too low - if there is any at all - for such combustion. In this case there is an air supply device 27, which comprises an intake-sided air filter 28 and an electrically driven blower 29. The air supply device 27 is connected to the main exhaust pipe 12 by way of an air supply pipe 30, which empties into the main exhaust pipe. Through said air supply pipe an air-enriched exhaust gas flows into the mixing chamber 15. To achieve complete combustion, there is a sensor, e.g. a lambda probe 31, which measures the oxygen content in the exhaust gas, in front of the opening of the air supply pipe into the main exhaust pipe 30. The air supply is controlled by way of the blower 29 as a function of this oxygen content.

Patent Claims

1. Device for producing mechanical energy, comprising an internal combustion engine and an expansion engine (20, 21), which is fed with superheated steam from a steam generator (24), whereby the exhaust gases of the internal combustion engine are injected into the steam generator (24) to use the waste heat thereof, **characterized in that** the steam generator (24) is heated by a non-catalytic burner (16) at a burner temperature ranging from 1,100° to 1,300° C, and that the exhaust gases of the internal combustion engine are fed to the burner (16).

2. Device, as claimed in claim 1, **characterized in that** the non-catalytic burner (16) is a porous burner.

3. Device, as claimed in claim 1 or 2, **characterized in that** the non-catalytic burner (16) and the internal combustion engine can be operated with the same type of fuel.

4. Device, as claimed in any one of the claims 1 to 3, **characterized in that**
   (a) a mixing chamber (15), into which the hot exhaust gases of the internal combustion engine are injected, is upstream of the burner (16), and

   (b) fuel can be injected into the hot exhaust gases to produce a combustible gas for the burner (16).

5. Device, as claimed in any one of the claims 1 to 4, **characterized in that** the burner (16) is connected to the air supply means.

6. Device, as claimed in claims 4 and 5, **characterized in that** the air supply means feed combustion air through an air supply pipe (30) into an exhaust gas line (12) upstream from its opening into the mixing chamber (15).

7. Device, as claimed in claim 6, **characterized in that**

   (a) the air supply means exhibit a blower (29); and

   (b) upstream of the discharge of the air supply pipe (30) into the exhaust gas line (12) a sensor (31) is disposed to measure the oxygen content in the exhaust gas; and

   (c) the blower (29) is controllable as a function of this oxygen content.

8. Device, as claimed in any one of the claims 1 to 7, **characterized in that** downstream of the burner (16) is a pollutant catalyst (18).

9. Device, as claimed in any one of the claims 1 to 8, **characterized in that** downstream of the burner (16) is a soot filter.

10. Device, as claimed in claim 8 or 9, **characterized in that** the pollutant catalyst and/or the soot filter is/are disposed upstream of the steam generator (24).

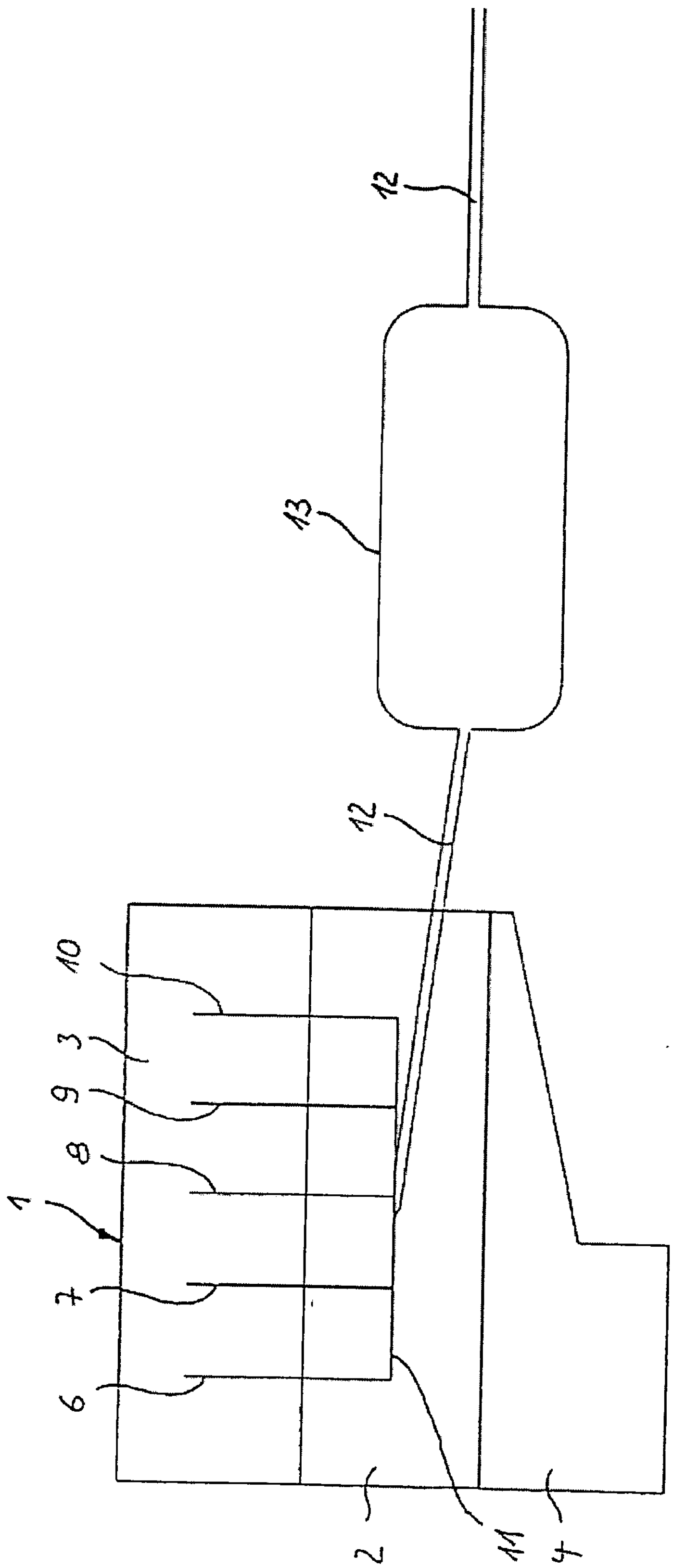

Fig. 1

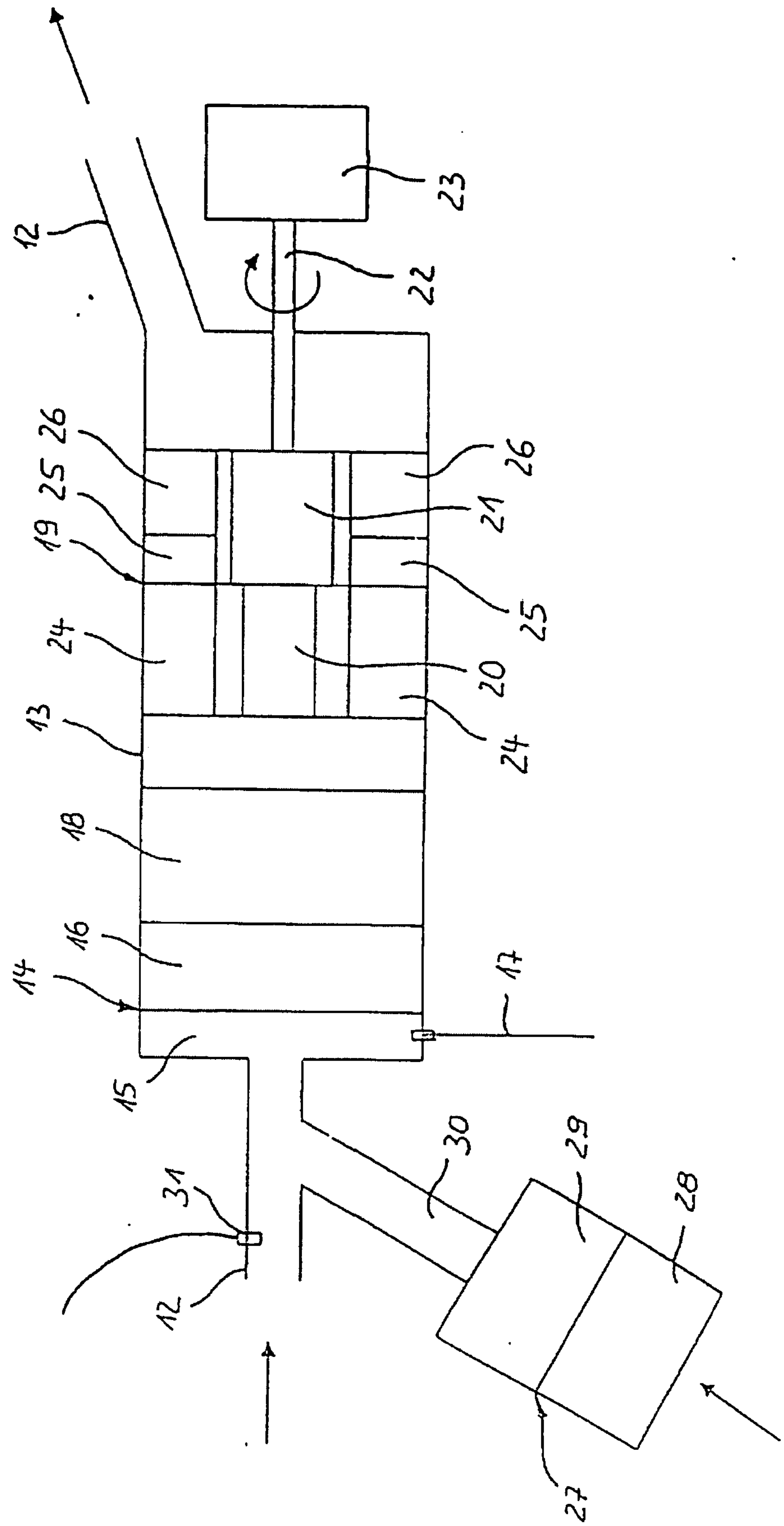

Fig. 2

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